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Art. XVI.—*Gold Specimens from Bendigo and their Probable Modes of Origin.*

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(Plate I.)

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The gold in the Bendigo quartz reefs occurs as particles of bright, yellow, free gold, of high quality, containing about 30 parts per 1000 of silver. Its occurrence can be divided into two general types—

(a) As particles associated with the dark laminated seams traversing the quartz;

(b) as particles embedded in white quartz.

While these two general types are not confined to any particular form of reef, it can be said that the first type is more characteristic of saddle reefs and leg reefs, and that the second type is more characteristic of "spurs," which are veins cutting across the strata. The gold particles in the spurs are, on an average, larger than the gold particles associated with the carbonaceous seams, but the latter may be more numerous, and have formed the main factor in the richest saddle reefs of Bendigo. Such particles are occasionally so numerous as to form a sheet of gold along the lamina.[1]

The particles of gold embedded in white quartz appear as shotty specks, or as sheeted interlacings with quartz, and sometimes ankerite. The gold particles, like quartz, are allotriomorphic, and do not assume their crystalline form except in rare cases in vugs. The tendency of the gold towards its crystalline form is, however, often sufficient to produce more or less rounded, shotty particles, unless there exist obstructing or modifying circumstances. The shotty particles sometimes are readily loosened and detached from the quartz, and are then spoken of as "loose gold." The modifying circumstances may develop during the later stages of growth of a vein if the quartz crystals grow at a more rapid rate than the gold crystals, or if the growth of the

1. Gold Deposition in the Bendigo Goldfield. F. L. Stillwell, Bull. 4, Commonwealth Adv. Council of Sci. and Ind., plate III., fig. 2.

quartz crystals continues for a longer period than required for the gold crystals. The tremendous crystallising pressure of the quartz, which is sufficient to force apart the walls of the vein, may then be partially directed against the growing crystals of gold, modifying them in the same way that gold is hammered in the production of gold leaf. In this case the final result is a sheeted interlacing of gold with quartz, ankerite, and other minerals, with an appearance that has often suggested the infiltration of secondary gold in cracks in a quartz vein.

The specimen illustrated in Fig. 1 came from the Constellation saddle reef above the 622 feet level. It shows a black slaty seam, partly mixed with ankerite, pursuing its normal tortuous track through the quartz. Several particles of gold, pyrite and galena occur in this specimen along this carbonaceous seam, including a well-formed cube of pyrite. Particles of gold are embedded in the cube of pyrite, and appear to have formed the nucleus of the crystal.

Another specimen, occurring near this cube in the same saddle reef, shows an intimate mixture of gold, galena and pyrite. The mixture borders upon a carbonaceous lamina, visible on the side of the specimen, but which is not revealed in the photograph (fig. 2). The photograph illustrates a sliced surface of the specimen on which only a few fragments of carbonaceous matter are showing, but pyrite (P), gold (white), and galena (Ga) are distinguishable. The mass of pyrite is embedded in quartz, but at the same time it is broken by veins of quartz, galena and gold. The gold appears not only as nuclei of some of the pyrite, but also as a network of veins in the pyrite, and in the galena.

Without consideration of the process of formation of the vein, the petrographical relations of the quartz and pyrite in these two specimens would indicate that—(1) pyrite crystallised before gold, and (2) that gold crystallised before pyrite. The apparently contradictory character of these conclusions appears to me to disappear when the vein is viewed as a slow and steady growth, in which the quartz and each other mineral are slowly and continuously deposited from the initial stages up to the final stages of the formation of the vein. The gold, pyrite and galena are localised in the quartz in these instances, partly by the precipitating action of the slaty residues, and, in a growing mixture of gold and pyrite, some of the pyrite may be precipitated before some of the gold, and some of the gold before some of the pyrite. The mutual relationships of the solubilities and concentrations of the different vein minerals, which might have been expected to produce a more or less characteristic order of deposition have been disturbed by the presence of foreign precipitating matter.

A specimen of a different and rare type at Bendigo is illustrated in Fig. 3. It consists of a thin plate of gold, with a small fragment of attached quartz, terminating in a crystal of gold. The specimen is 3 cm. long, weighs 2 dwts. 14 grs., and is shown in the photograph with a magnification of 2. It was found in a quartz spur in sandstone about two feet wide in the stopes on the Victory spurs, 580 feet south, 1235 feet level, in the Carlisle mine. The gold crystal occurred in a vug, terminating the plate of gold in the same way as the associated quartz crystals in the same vug grew out from the mass of quartz. The dominating faces of the crystal are those of the octahedron. The solid angles of the octahedron are replaced by small faces of the cube, and the edges of the octahedron are replaced by faces of the rhombicdodecahedron. For nearly 1cm. behind the terminating crystal, crystalline faces of gold can be seen on the plate of gold. It is quite clear that this small nugget of gold is as essential and primary a part of the vein as the quartz crystals that form the bulk of the vein. Had the gold not assumed the platy and crystalline form, the occurrence might have been similar to the gold wire whose occurrence in a quartz vug has previously been recorded.[2]

Another rare specimen obtained from the same stopes, at the 1235 feet level, in the Carlisle mine, is illustrated in Fig. 4. This is a fragment of a very small, but very rich, spur, which traversed a thick bed of slates on the eastern side of the stopes. The thickest part of the vein in the specimen is 5 mm., in which are embedded two isolated crystals of sphalerite, with a little admixed pyrite. A few small specks of gold are embedded in the quartz, but the main mass of gold in the specimen occurs as a thin film, bounding the quartz and the slate. The gold film shows irregularities, but is fairly continuous, and, when the slate is broken away, has the appearance of gold paint on the wall of the vein. Towards one end of the specimen the thick-

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2. The Factors Influencing the Deposition of Gold in the Bendigo Goldfield. F. L. Stillwell, Bull. No. 8, Adv. Council of Sci. and Industry, plate V., fig. 2.

ness of the quartz vein diminishes, and becomes almost pure gold. An interesting feature of the specimen is shown in the illustration, and consists of a number of gold platy riffles standing out from the vein at right angles to the wall. These riffles are on the whole parallel to the cleavage of the slate, and represent gold that has been deposited in the cleavage cracks from solutions traversing the course of the vein. The feature exists on both sides of the vein. It is very clear from this specimen that the slate has been a precipitating agent for the gold.

Another specimen from the same gold shoot, and the same mine, can also be recorded, though it does not lend itself to illustration. It was obtained from the 1264 feet level, adjoining the plane of a small west dipping fault. A spur, which varies in thickness from ½ inch to 1½ inches, butts against the fault plane, and contains pyrite and colours of gold. Projecting from the wall of a small branching spur, which forms the fault plane, is a nest of pyrite cubes, and the wall of the fault and spur is mostly covered with a film of gold, which also extends into the fractures of the associated slate. These two specimens are rare, and at first glance the films of gold paint suggest the occurrence of secondary gold, i.e., gold which has been leached from the gold-bearing spurs, and precipitated by the slate. The small fault is believed to have existed prior to the vein formation, and gold might have been precipitated from the primary solutions circulating along it, or from subsequent secondary solutions. The great depth of the occurrence of 1264 feet below the surface is a fact in strong opposition to a theory of downward secondary enrichment, while the association of the gold with the sulphides is more consistent with its being of primary origin. Even if it were claimed that these occurrences indicate the presence of secondary gold, it must be remembered that they are rare. Frequent inspections of mining operations on this gold shoot in the Carlisle mine, which, during the fourteen months preceding September, 1921, produced 15,712 ounces of gold, valued at £84,761, failed to yield any evidence recognisable as being characteristic of secondary enrichment. It may therefore be fairly concluded that the gold in the spurs is primary, and that the existence of the gold shoot is dependent on primary causes.

PLATE I.

Fig. 1. Quartz, showing gold (dark), embedded in a cube of pyrite. From saddle reef above 622 feet level, Constellation mine. Mag. 2.

Fig. 2. Quartz carrying pyrite gold and galena. The pyrite (P) is intersected by veins of quartz, galena (Ga) and gold (white). From saddle reef above 622 feet level, Constellation mine. Mag. 2.

Fig. 3. Thin plate of gold terminating in a crystal of gold. Stopes 580 feet south, 1235 feel level, Carlisle mine. Mag. 2.

Fig. 4. Rich spur in slate, showing a number of gold platy riffles standing out from the vein at right angles to the wall of the spur. The dark area (B) is a crystal of zinc blende embedded in the vein, and the hackly appearance of the edge of the vein is due to gold. Eastern side of stopes, 580 feet south, 1235 feet level, Carlisle mine. Mag. 2.